

FEDERAL AVIATION AGENCY

Washington 25, D. C.

TECHNICAL STANDARD ORDER

Regulations of the Administrator

Part 511

**SUBJECT: DIRECTION INSTRUMENTS (MAGNETIC)
(MAGNETIC COMPASS)**

TSO-C76

**Technical Standard Orders for Aircraft Materials,
Parts, Processes, and Appliances**

Part 511 contains minimum performance standards and specifications of materials, parts, processes, and appliances used in aircraft and implements the provisions of sections 3.18, 4a.18, 6.18 and 7.18 of the Civil Air Regulations. The regulation uses the Technical Standard Order system which, in brief, provides for FAA-industry cooperation in the development of performance standards and specifications which are adopted by the Administrator as Technical Standard Orders, and a form of self-regulation by industry in demonstrating compliance with these orders.

Part 511 consists of two subparts. Subpart A contains the general requirements applicable to all Technical Standard Orders. These provisions are summarized below for the convenient reference of the public. Subpart B contains the technical standards and specifications to which a particular product must conform, and each Technical Standard Order is set forth in the appropriate section of Subpart B. The subject Technical Standard Order is printed below. ANY TECHNICAL STANDARD ORDER MAY BE OBTAINED BY SENDING A REQUEST TO FAA, WASHINGTON 25, D. C.

SUBPART A--GENERAL

This subpart provides, in part, that a manufacturer of an aircraft material, part, process, or appliance for which standards are established in Subpart B, prior to its distribution for use on a civil aircraft of the United States, shall furnish a written statement of conformance certifying that the material, part, process, or appliance meets the applicable performance standards established in this part. The statement of conformance must be signed by a person duly authorized by the manufacturer, and furnished to the Chief, Engineering and Manufacturing Division, Bureau of Flight Standards, Federal Aviation Agency, Washington 25, D. C.

Subpart A also requires appropriate marking of materials, parts, processes, and appliances as follows:

- (a) Name and address of the manufacturer responsible for compliance,
- (b) Equipment name or type or model designation,
- (c) Weight to the nearest pound and fraction thereof,
- (d) Serial number and/or date of manufacture, and
- (e) Applicable Technical Standard Order (TSO) number.

In addition, Subpart A provides that no deviation will be granted from the performance standards established in Subpart B, and that the Administrator may take appropriate action in the event of noncompliance with Part 511.

SUBPART B

§514.17 Direction instrument, magnetic, non-stabilized type (magnetic compass) - TSO-C7c--(a) Applicability--(1) Minimum performance standards. Minimum performance standards are hereby established for direction instruments, magnetic, non-stabilized type (magnetic compass) which specifically are required to be approved for use on civil aircraft of the United States. New models of direction instruments, magnetic, non-stabilized type (magnetic compass) manufactured for installation on civil aircraft on or after April 1, 1959, shall meet the standards set forth in SAE Aeronautical Standard AS-398A, "Direction Instrument, Magnetic, Non-Stabilized Type (Magnetic Compass)", dated July 15, 1958, with the exceptions listed in subparagraph (2) of this paragraph. Direction instruments, magnetic, non-stabilized type (magnetic compass) approved by the Administrator prior to April 1, 1959, may continue to be manufactured under the provisions of their original ~~approval~~.

(2) Exceptions. (i) Conformance with the following Sections is not required: 3.1; 3.1.1; 3.1.2; 3.2; 4.3.3.

(ii) Substitute the following for section 7.: "Performance tests: The following tests in addition to any others deemed necessary by the manufacturer, shall be the basis for determining compliance with the performance requirements of this standard."

(b) Marking. In lieu of the weight ~~specified in paragraph (c) of §514.3, the following shall be shown:~~

(1) Instrument type (I or II)

(2) Rating if applicable, i.e. electrical, vacuum, etc.


(c) Data requirements. One copy each of the manufacturer's operating instructions, schematic diagrams, and installation procedures shall be furnished the Chief, Engineering and Manufacturing Division, Federal Aviation Agency, Washington 25, D.C. 8 with the statement of conformance.

(d) Effective date. April 1, 1959.

1/Copies may be obtained from the Society of Automotive Engineers, Inc., 485 Lexington Ave., New York 17, New York.

DIRECTION INSTRUMENT, MAGNETIC, NON-STABILIZED TYPE
(Magnetic Compass)

Issued 7-1-47
Revised 7-15-58

1.  Specify minimum requirements for non-stabilized magnetic direction instruments for use in aircraft, the operation of which may subject the instrument to the environmental conditions specified in Paragraph 3.3.

2. SCOPE: This Aeronautical Standard covers two basic types of instruments as follows:

Type I - Direct Reading
Type II - Remote Indicating

3. GENERAL REQUIREMENTS:

3.1 Material and Workmanship:

3.1.1 Materials: Materials shall be of a quality which experience and/or tests have demonstrated to be suitable and dependable for use in aircraft instruments.

3.1.2 Workmanship: Workmanship shall be consistent with high-grade aircraft instrument manufacturing practice.

3.2 Identification: The following information shall be legibly and permanently marked on the instrument or attached thereto:

- (a) Name of Instrument
- (b) Aeronautical Standard AS 398A
- (c) Manufacturer's part number
- (d) Manufacturer's serial number or date of manufacture
- (e) Manufacturer's name and/or trademark
- (f) Rating, if applicable (Electrical, Vacuum, etc.)

3.3 Environmental Conditions: The following conditions have been established as design requirements only. Tests shall be conducted as specified in Sections 5, 6 and 7.

3.3.1 Temperature: When installed in accordance with the instrument manufacturer's instructions, the instrument shall function over the range of ambient temperature shown in Column A below and shall not be adversely affected by exposure to the range of temperature shown in Column B below:

Instrument Location	A	B
Heated Areas (Temperature Controlled)	- 30 to 50C	- 65 to 70C
Unheated Areas (Temperature Uncontrolled)	- 55 to 70C	- 65 to 70C

3.3.2 Humidity: The instrument shall function and shall not be adversely affected when exposed to any relative humidity in the range from 0 to 95% at a temperature of approximately 32C.

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- 3.3.3 Vibration:** When installed in accordance with the instrument manufacturer's instructions, the instruments shall function and shall not be adversely affected when subjected to vibrations of the following characteristics:

<u>Instrument Location in Airframe</u>	<u>Cycles Per Sec.</u>	<u>Max. Double Amplitude (Inches)</u>	<u>Max. Acceleration</u>
Power Plant Mounted	5 - 150	0.100	20g
Wings and Empennage	5 - 500	0.036	10g
Panel or Rack (with Shockmounts)	5 - 500	0.020	165g

- 3.3.4 Altitude:** The instrument shall function and shall not be adversely affected when subjected to a pressure and temperature range equivalent from 4000 feet to 40,000 feet standard altitude per NACA Report 1235, except as limited by application of Paragraph 3.3.1. The instrument shall not be adversely affected when subjected to a pressure of 50 In. Hg. baseline.

- 3.4 Radio Interference:** The instrument shall not be the source of objectionable interference, under operating conditions at any frequencies used on aircraft either by radiation or feed-back, in radio equipment installed in the same aircraft as the instrument.

- 3.5 Magnetic Effect:** The magnetic effect of the instrument shall not adversely affect the operation of other instruments installed in the same aircraft.

4. DETAIL REQUIREMENTS:

- 4.1 Indicating Method:** One of the following methods of indication shall be employed:

Method I	Horizontal drum dial with fixed lubber's line. Graduations move to the right for right turns.
Method II	Rotating vertical dial with fixed lubber's line. Dial rotates counter-clockwise for right turns.
Method III	Rotating pointer with fixed graduated dial. Pointer rotates clockwise for right turns. Dial position may be adjustable.

- 4.2 Operating Limits:** During straight flight the instrument shall indicate magnetic headings, throughout the 360 degree scale range, during dives, climbs or banks up to at least 20 degrees displacement from level flight.

- 4.3 Dial Markings**

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- 4.3.1 Graduations: The indicators shall be provided with degree graduations at intervals not to exceed 5 degrees, with major graduations every 10 degrees and with numerical markings at intervals not greater than 30 degrees, except that the 0, 90, 180 and 270 degree positions shall be marked N, E, S and W respectively.
- 4.3.2 Visibility: Index and dial markings shall be visible from any point within the frustum of a cone the side of which makes an angle of 30 degrees with the perpendicular to the dial and the small diameter of which is the maximum of the instrument case. At least two materials shall be ~~used~~ ^{alternately} visible.
- 4.3.3 Finish: Unless otherwise specified by the user, matte white material shall be applied to major graduations, numerals and pointers. Non-functional surfaces shall be a durable dull black.
- 4.4 Power Variations: All units shall properly function with $\pm 15\%$ variation in D.C. voltage and/or $\pm 10\%$ variation in A.C. voltage and a $\pm 5\%$ frequency variation.
- 4.5 Compensation Provisions: Means shall be provided for compensating for circular deviation. Compensating effect shall be between 15 and 40 degrees in each direction for each axis when adjusted for maximum effect.
- 4.6 Power Malfunction Indication: Means shall be incorporated in the instrument to indicate when adequate power (voltage and/or current) is not being made available to all phases required for the proper operation of the instrument. The indicating means shall indicate failure or a malfunction in a positive manner.

5. TEST CONDITIONS:

- 5.1 Atmospheric Conditions: Unless otherwise specified, all tests required by this Aeronautical Standard shall be conducted at an atmospheric pressure of approximately 29.92 inches of mercury, at an ambient temperature of approximately 29° and a relative humidity of not greater than 85 percent. When tests are conducted with atmospheric pressure or temperature substantially different from these values, allowance shall be made for the variations from the specified conditions.
- 5.2 Vibration (to minimize friction): Unless otherwise specified, all tests for performance may be conducted with the instrument subjected to a vibration of 0.002 to 0.005 inch double amplitude at a frequency of 1500 to 2000 cycles per minute. The term double amplitude as used herein indicates the total displacement from positive maximum to negative maximum.
- 5.3 Vibration Equipment: Vibration equipment shall be used which will provide frequencies and amplitudes consistent with the requirements of Paragraph 3.3.3 with the following characteristics:

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- 4.3.1 Graduations: The indicators shall be provided with degree graduations at intervals not to exceed 5 degrees, with major graduations every 10 degrees and with numerical markings at intervals not greater than 30 degrees, except that the 0, 90, 180 and 270 degree positions shall be marked N, E, S and W respectively.
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- 4.5 Compensation Provisions: Means shall be provided for compensating for circular deviation. Compensating effect shall be between 15 and 40 degrees in each direction for each axis when adjusted for maximum effect.
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5. TEST CONDITIONS:

- 5.1 Atmospheric Conditions: Unless otherwise specified, all tests required by this Aeronautical Standard shall be conducted at an atmospheric pressure of approximately 29.92 inches of mercury, at an ambient temperature of approximately 29° and a relative humidity of not greater than 85 percent. When tests are conducted with atmospheric pressure or temperature substantially different from these values, allowance shall be made for the variations from the specified conditions.
- 5.2 Vibration (to minimize friction): Unless otherwise specified, all tests for performance may be conducted with the instrument subjected to a vibration of 0.002 to 0.005 inch double amplitude at a frequency of 1500 to 2000 cycles per minute. The term double amplitude as used herein indicates the total displacement from positive maximum to negative maximum.
- 5.3 Vibration Equipment: Vibration equipment shall be used which will provide frequencies and amplitudes consistent with the requirements of Paragraph 3.3.3 with the following characteristics:

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- 6.5 Heeling Errors When the magnetic-sensitive unit is tilted 20 degrees from the normal level position the magnetic element shall be free to rotate through 360 degrees. When the unit is tilted 10 degrees the indicated heading shall not differ from the indicated heading with the magnetic-sensitive unit in normal level position by more than 4 degrees. The indicator dial (or pointer) shall still be visible as specified in Paragraph 4.3.2.
- 6.6 Swirl: When the magnetic-sensitive unit is tilted 20 degrees from normal and rotated in azimuth, at a rate of 30 degrees per second, through 360 degrees, stopping at N, S, E and W indication, the overrunning of the indicator dial (or pointer) at each of these points shall not exceed 6 degrees.
- 6.7 Compensation: With the magnetic-sensitive unit on N Lading and the compensator adjusted for abeam effect, the scale error with the compensator shall not differ from the scale error without compensator by more than 2 degrees. The maximum adjustable compensation effect $\bullet \approx \odot \bullet$ be between 15 and 40 degrees in each direction for each axis.

When the magnetic-sensitive unit is placed on any cardinal heading and the opposite axis compensator adjusted for maximum effect the indicated heading shall not change more than 2 degrees.

- 6.8 Dielectric: Ungrounded instruments or grounded instruments prior to connection of internal ground wire, shall be tested by either the method of Inspection of Paragraph 6.8.1 and 6.8.2.
- 6.8.1 Insulation Resistance: The insulation resistance measured at 500 volts D.C. (200 volts for hermetically sealed, inert gas filled instruments) between all electrical circuits connected together and the metallic cast shall not be less than 20 megohms.
- 6.8.2 Dielectric Strength The insulation shall withstand without evidence of damage the application of 8 sinusoidal voltage at 8 commercial frequency between all electrical circuits connected together and the metallic case, for a period of five seconds. The RMS value of the sinusoidal voltage applied shall be either five (5) times the maximum instrument operating voltage, or 500 volts, whichever is lower, except that on hermetically sealed, (inert gas filled instruments) the test voltage shall be 200 volts RMS.
- 6.8.2.1 Instruments having a permanent internal ground connection shall be tested as follows:

The insulation shall withstand without evidence of damage the application of 8 sinusoidal voltage at 8 commercial frequency between each electric circuit and the metallic case, for a period of five (5) seconds. The RMS value of the sinusoidal voltage applied shall be 1.25 times the maximum circuit operating voltage obtainable between the test points.

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70 QUALIFICATION TESTS: As many instruments as deemed necessary to demonstrate that all instruments will comply with the requirements of this section shall be tested in accordance with the manufacturer's recommendations.

701 Low Temperature: The instruments, or components, shall be subjected to the temperatures indicated in the following table in accordance with their location in the aircraft. After exposure to these temperatures for 5 hours, rated performance shall be obtained in 15 minutes after application of rated power using the magnetic field strength specified in Paragraph 5.6 except the field strength tolerance shall be $\pm 20\%$.

Instrument Location**Temperature**

Heated Area (Temperature Controlled)

-30C

Unheated Area (Temperature Uncontrolled)

-45C

702 High Temperature: The requirements of Paragraph 7.1 shall apply except that the exposure temperatures shall be 50C for heated areas and 70C for unheated areas and rated performance shall be obtained in 3 minutes after application of rated power.

703 Extreme Temperature Exposure: The instrument, or components, shall, after alternate exposures to ambient temperatures of -65C and 70C for periods of 2 hours each and duty of 3 hours at room temperature following completion of the exposure, meet the requirements of Paragraph 6.1 and 6.2. There shall be no evidence of damage as a result of exposure to the extreme temperatures specified herein.

704 Magnetic Effects The magnetic effect of the Type II indicator shall be determined in terms of the deflection of a free magnet, approximately 1 1/2 inches long in a magnetic field with a horizontal intensity of 0.18 (0.01) gauss when the indicator is held in various positions on an east-west line with its nearest part 12 inches from the center of the magnet. This test shall first be made with the indicator not operating and then shall be repeated with the indicator in normal operation. The maximum deflection of the free magnet shall not exceed 5 degrees for any pointer or dial position.

705 Humidity: The instrument (indicator, transmitter, amplifier, etc.) shall be mounted in a chamber maintained at a temperature of 70 ± 2 C and a relative humidity of $95 \pm 5\%$ for a period of six hours. After this period the heat shall be shut off and the instrument shall be allowed to cool for a period of 16 hours in this atmosphere in which the humidity rises to 100% as the temperature decreases to not more than 38 C. This complete cycle shall be conducted:

a. Five times for components located in uncontrolled temperature areas.

b. Once for components located in controlled temperature areas.

Immediately after recycling, there shall be no evidence of damage or corrosion which affects performance, following this test, and the instrument shall meet the requirements of Section 6, except for Paragraph 6.8.

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7.6 Vibration:

Resonance - The instrument, while operating, shall be subjected to a resonant frequency survey of the appropriate range specified in Paragraph 3.3.3 in order to determine if there exists any resonant frequencies of the parts. The amplitude used may be any convenient value that does not exceed the maximum double amplitude and the maximum acceleration specified in Paragraph 3.3.3.

The instrument shall then be subjected to a vibration at the appropriate maximum double amplitude or maximum acceleration specified in Paragraph 3.3.3 at the resonant frequency for a period of one hour in each axis or with circular motion vibration, whichever is applicable. When more than one resonant frequency is encountered with vibration applied along any one axis, a test period may be accomplished at the most severe resonance, or the period may be divided among resonant frequencies, whichever shall be considered most likely to produce failure. The test period shall not be less than one-half hour at any resonant mode. When resonant frequencies are not apparent within the specified frequency range, the instrument shall be vibrated for two hours in accordance with the vibration requirements schedule (Paragraph 3.3.3) at the maximum double amplitude and the frequency to provide the maximum acceleration.

Cycling - The instrument, while operating, shall be tested with the frequency cycled between limits specified in Paragraph 3.3.3 in 15 minute cycles for a period of one hour in each axis at an applied double amplitude specified in Paragraph 3.3.3, or an acceleration specified in Paragraph 3.3.3 whichever is the limiting value or a total of those hours for circular motion vibration, whichever is applicable.

The instrument shall be tested during vibration to determine that it is functioning properly. After the completion of this vibration test, no damage shall be evident and the instrument shall meet the requirements of Section 6 (other than Paragraph 6.8).

